National Transportation Safety Board
Office of Research and Engineering
Washington, DC 20594

CEN22FA383

MULTIPLE ELECTRONIC DEVICES

Specialist's Factual Report

November 18, 2022

A. ACCIDENT

Location: Hanna City, IL
Date: August 13, 2022
Time: 12:31 central daylight time (CDT)
17:31 Universal Coordinated Time (UTC)
Airplane: Mooney Aircraft Corp M20K, N30EV

B. SPECIALIST

Specialist: Sean Payne
Sr. Engineer
National Transportation Safety Board (NTSB)

C. DETAILS OF THE INVESTIGATION

The NTSB Vehicle Recorder Division received the following electronic devices:

Recorder Manufacturer/Model: Shadin MiniFlo
Recorder Serial Number: 8746

Recorder Manufacturer/Model: Appareo Stratus 1s
Recorder Serial Number: 1s002339

Recorder Manufacturer/Model: JPI EDM-700
Recorder Serial Number: 1685

Recorder Manufacturer/Model: Garmin GPSMAP 396
Recorder Serial Number: 20210349

1.0 Device Description

Shadin MiniFlo Digital Fuel Flow Indicator

The Shadin Avionics Miniflo is a digital fuel management system designed to provide fuel management information under real time flight conditions to the flight crew. The unit is connected to engine fuel flow transducers. The unit can display the following information to the crew:

- Fuel Flow (gallons per hour, gph)
- Fuel Used (gallons, gal)
- Fuel Remaining (gallons, gal)

The unit does not interface with an aircraft's fuel quantity indicating system. The unit requires the flight crew to enter the initial fuel on board the aircraft. All calculations and data provided by the unit are based on fuel flow and any provided navigational information.

Appareo Stratus 1s

The Appareo Status device is a self-contained battery powered unit that contains an internal AHRS, GPS/WAAS receiver, and ADS-B receiver in one compact unit.[1, 2, 3] The unit communicates wirelessly with the pilot's iPad or iPhone ("iOS Device") to display all the acquired information. The pilot needs to have a particular software application called ForeFlight installed on their iOS Device to view the Stratus data.[4] In addition to communicating with the iOS Device, the Stratus device records GPS position and AHRS information internally on a non-volatile flash memory (NVM) chip. Internal memory has the space to store over 13 hours of data.[5]

JPI EDM-700

The J. P. Instruments EDM-700/800 is a panel mounted gauge that allows the operator to monitor and record up to 24 parameters related to engine operations. Depending on the installation engine parameters monitored can include:

- Exhaust Gas Temperature
- Cylinder Head Temperature
- Oil Pressure (pounds per square inch or psi) and Temperature
- Manifold Pressure
- Outside Air Temperature
- Turbine inlet Temperature
- Engine Revolutions per Minute
- Compressor Discharge Temperature

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[1] The Attitude Heading Reference System consists of a set of 3-axis gyroscope, accelerometers and heading reference sensors that enable the unit to compute pitch, roll, and yaw motions.
[2] The Wide Area Augmentation System (WAAS) is an air navigation aid to augment the Global Positioning System (GPS), by improving its accuracy, integrity, and availability.
[3] Automatic Dependent Surveillance-Broadcast (ADS-B) is a surveillance technology deployed throughout the national airspace system. The ADS-B system is composed of aircraft avionics and a ground infrastructure. Onboard avionics determine the position of the aircraft by using the GNSS and transmit its position along with additional information about the aircraft to ground stations for use by ATC and other ADS-B services. This information is transmitted at a rate of approximately once per second. Operators equipped with ADS-B realize additional benefits from ADS-B broadcast services: Traffic Information Service - Broadcast (TIS-B) (traffic information) and Flight Information Service - Broadcast (FIS-B) (weather information).
[4] iOS Device app (program) that communicates wirelessly with the Appareo Status unit to display aircraft's
attitude, navigation, weather, and traffic information.
[5] Type of solid state memory that does not require electrical power to retain information.

- Fuel Flow
- Carburetor Temperature
- Battery Voltage

The unit can also calculate, in real-time, horsepower, fuel used, shock cooling rate and EGT differentials between the highest and lowest cylinder temperatures. The calculations are also based on the aircraft installation. The unit contains non-volatile memory for data storage of the parameters recorded and calculated. The rate at which the data is stored is selectable by the operator from 2 to 500 seconds per sample. The memory can store up to 20 hours of data at a 6 second sample rate. The data can then be downloaded by the operator using the J.P. Instruments software.

Garmin GPSMAP 396

The Garmin GPSMAP 396 is a battery-powered portable 12-channel GPS receiver with a 256-color TFT LCD display screen. The unit includes a built-in Jeppesen database and is capable of receiving XM satellite radio for flight information including NEXTRAD radar, lightning, METARs, TAFs, and TFRs. The unit stores date, route-of-flight, and flight-time information for up to 50 flights. A flight record is triggered when groundspeed exceeds 30 knots and altitude exceeds 500 feet, and ends when groundspeed drops below 30 knots for 10 minutes or more. A detailed tracklog including latitude, longitude, date, time, and GPS altitude information is stored within the unit whenever the receiver has a lock on the GPS navigation signal. Position is updated within the tracklog as a function of time or distance moved, depending on how the unit has been configured. Once the current tracklog memory becomes full, new information either overwrites the oldest information or recording stops, depending on how the unit is configured. The current tracklog can be saved to long-term memory and 15 saved tracklogs can be maintained in addition to the current tracklog. Tracklog storage may be activated or de-activated at user discretion. All recorded data is stored in NVM. The unit contains hardware and software permitting the download of recorded waypoint, route, and tracklog information to a PC via a built-in serial port using the NMEA 0183 version 2.0 protocol. The unit can also communicate with external devices such as a computer using a built in USB port. An internal button-battery is used to back-up power to the internal memory and real-time clock during those periods when main power is removed.

1.1 Data Recovery

Shadin MiniFlo Digital Fuel Flow Indicator

The device is pictured in Figure 1. The device appeared mostly undamaged with the exception of a dent. The device was powered as per the installation manual. The device displayed the following when the appropriate switches were manipulated:

Fuel Flow – 0.0 gph, Gal. Used – 64.9 gal, Gal Rem. (Remain) – 10.1 gal

Figure 2 is a photograph of the GAL. USED and GAL. REM. switches manipulated.

Figure 1. Photo of Shadin Miniflo.

Figure 2. Photo of GAL. USED (top) and GAL. REM. (bottom) displayed.

Note that the calculations of fuel status in this device are dependent on the user properly setting the fuel status at the beginning of each power cycle.

Appareo Stratus 1s

The Appareo Stratus 1s is pictured in Figure 3. The device's outer white case was slightly disjointed, but there was no obvious damage to the functionality of the unit. The device was charged with a USB-C cable and powered. The device powered normally and connected to laboratory iPad running the electronic flight bag (EFB) application Foreflight. Foreflight showed that the device's logging function was turned off (Figure 4). No track logs were discovered on the device. No data relevant to the accident flight was recovered from the device.

Figure 3. Photo of Appareo Stratus 1s.

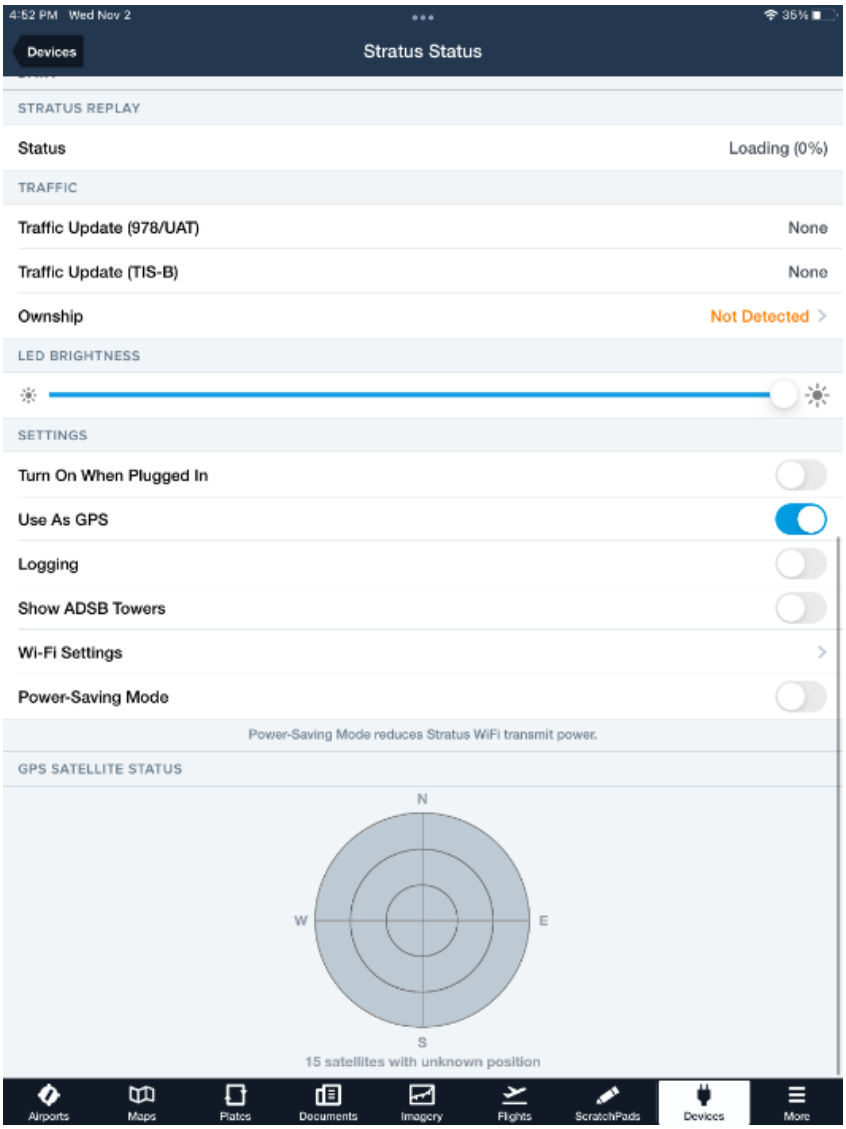

Figure 4. Screen capture of laboratory iPad running Foreflight when connected to the accident Stratus 1s. Note that logging is turned off.

JPI EDM-700

The JPI EDM-700 is pictured in Figure 5. The device's outer casing was damaged and the screen was loose. The device was removed from its outer casing and the screen was repaired. When removed from the outer casing, the internal components of the device indicated that it lacked the hardware functionality to record data. Some old model JPI EDM-700 do not record data. The unit in this accident did not record data. Figure 6 shows the unit only contained two boards internally and lacked the third board necessary to record data.

Figure 5. Photo of JPI EDM-700 as received.

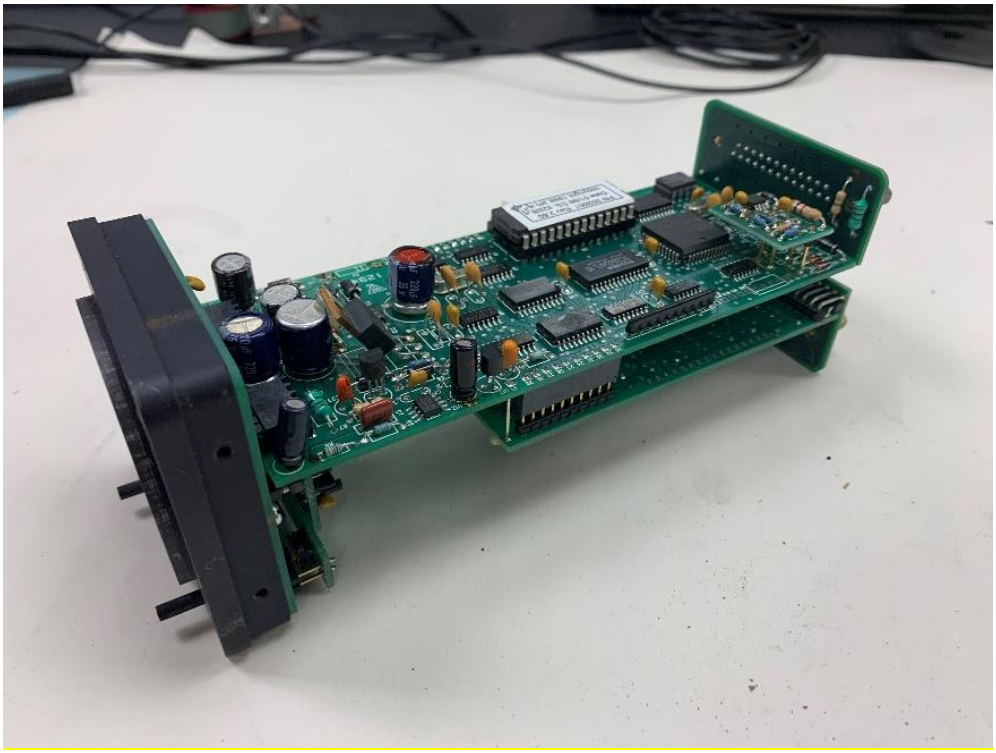

Figure 6. Photo of JPI EDM-700 internal components. Note that there are only two internal boards, and the device is missing the third board necessary to record data.

No data was recovered from the device.

Garmin GPSMAP 396

The device arrived at the laboratory exhibiting little obvious damage. The device is pictured in Figure 7. The device was plugged in to a PC via USB and powered normally. Tracklog data was extracted from the device and is discussed below in this report.

The device's pages and settings were explored for data relevant to the accident.

Figure 8 shows the "Flights" page. Each entry shows the date and the duration of the flight in hours. The device noted the "Last Flight" was 4 hours and 48 minutes and 51 seconds in duration. Note that the device needs to be powered by the user in order for logs to be created, and the "Flights" page may not capture all flights made by the aircraft. Additionally, since the device is portable, it could log flights from other sessions in aircraft other than the accident aircraft.

Figure 9 shows the device's "Aircraft Profile" tab in the "Aircraft" page. The profile tab lists the accident aircraft tail number and the fuel flow was entered by the user as 12.5 gallons per hour.

Figure 10 shows the “Active Route” page, as recovered. The page shows two waypoints, “DIRECT” which would be an entry from a GPS position when the route was entered, and “KPIA” (General Downing – Peoria Downtown International Airport, Peoria, IL).

Figure 11 shows an information page that displayed a fuel timer and a flight time. The values are as shown in the figure.

Figure 12 is the setup page for the “Timers” settings. The values are shown in the figure.

Figure 7. Photo of GPS as received.

Figure 8. Photo of “Flights” page.

Figure 9. Photo of "Aircraft Profile" tab in the "Aircraft" page.

Figure 10. Photo of "Active Route" page.

Figure 11. Photo of an information page that showed values for the fuel timer and flight timer. Note that these values may be representative of when the device powered off, which may have occurred after the accident.

Figure 12. Photo of the setup page for the "Timers" settings.

A discussion of tracklog data recovered from the device is presented below.

1.2 Garmin GPSMAP 396 Recording Description

The data extracted included several tracklog sessions. Recorded information ranged from April 11, 2022, to August 13, 2022 (the accident date). Only tracklog sessions determined to be relevant to the accident are discussed in this report.

1.3 Garmin GPSMAP 396 Parameters Provided

Table 1 describes data parameters provided by the GPS device. Date, Time, Latitude, Longitude, and GPS Altitude are recorded by the device. Groundspeed and Track are derived from the recorded parameters.

Table 1. GPS Data Parameters.

Parameter Name	Parameter Description (units)
Date	Date for recorded data point (MM/DD/YYYY)
Time	Time (UTC) for recorded data point (HH:MM:SS)
Latitude	Recorded Latitude (degrees)
Longitude	Recorded Longitude (degrees)
GPS Alt	Recorded GPS Altitude (feet)
Groundspeed	Average derived groundspeed (knots)
Track	Average derived true course (degrees)

D. GARMIN GPSMAP 396 OVERLAYS AND TABULAR DATA

Data obtained from the GPSMAP 396 was used to produce the following overlays and tabular data.

The weather and lighting conditions in Google Earth are not necessarily the weather and lighting conditions present at the time of the recording.

Figure 13 is a graphical overlay generated using Google Earth for a series of tracklogs that occurred on June 15, 2022. The data showed the aircraft on a route between southeast Florida and Santa Fe Regional Airport (KSAF), Santa Fe, New Mexico. During this cross-country flight, the aircraft appeared to make a stop at Majors Airport (KGVT), Greenville, TX. Due to discontinuities in the tracklog recordings, it is uncertain if the aircraft made a stop between southeast Florida and KGVT. The timing information showed the aircraft enroute between southeast Florida and KGVT for a duration of approximately 6 hours and 10 minutes.[6] For the second portion of the flight from KGVT to KSAF, the tracklog was continuous and the duration of the flight during which the aircraft was airborne was approximately 3 hours and 16 minutes.

Figure 14 is a graphical overlay generated using Google Earth showing the aircraft's operations at KSAF on August 10, 2022. The tracklog shows the aircraft flying one pattern at KSAF. The total duration of the recording that showed the aircraft was airborne was approximately 4 minutes.

Figure 15 is a graphical overlay generated using Google Earth showing the aircraft's tracks on the accident day from its departure from KSAF to the accident site. Tracklog information showed the session started at 12:36:03 UTC and ended near

[6] This calculation assumes the aircraft did not make a stop between the tracklog discontinues. For one discontinuity, groundspeed, time and distance calculations suggested the aircraft did not make a stop. For other discontinuities in this portion of the cross country, not enough information was recorded by the tracklog to make this calculation.

the wreckage location at 17:30:54 UTC. Specifically, the tracklog showed that takeoff roll at KSAF began at 12:38:50.

Figure 16 graphical overlay generated using Google Earth showing the aircraft's tracklog in the vicinity of the wreckage location. Around 17:19:16 the aircraft's tracklog went from a steady track to exhibiting a groundtrack change. The altitude at this time was recorded as 5351 feet GPS altitude and 189 knots groundspeed. From this time, the aircraft entered a steady descent until it reached the vicinity of the wreckage location around 17:30:52. The last data point showed the aircraft at 712 feet GPS altitude and 67 knots. The duration between these two points was 11 minutes and 36 seconds. The distance between the last recorded position and the closest runway threshold at KPIA was approximately 3.9 nautical miles. Note that in Figure 8, the route of flight was listed in the GPS device as KSAF (the departure airport) and KPIA.

Google Earth depicts terrain based on satellite imagery. The terrain features, such as the conditions of field, may not be accurately represented by Google Earth. Google Earth reports this imagery was captured between June 2016 (eastern portion of this figure's tracklog) and September 2022 (western portion of this figure's tracklog).

Figure 17 is a similar orientation to Figure 15, however a sectional chart for this region is overlaid.

Figure 18 graphical overlay generated using Google Earth showing a view along the tracklog of the aircraft toward the accident site. A sectional chart for this region is overlaid.

Figure 19 is a graphical overlay generated using Google Earth showing the final portion of the tracklog. The wreckage location is depicted as a yellow pin.

The corresponding tabular data used to create Figure 13 to Figure 19 are provided in electronic comma separated value (CSV) format as attachment 1 to this report.

Submitted by:

Sean Payne
Sr. Engineer

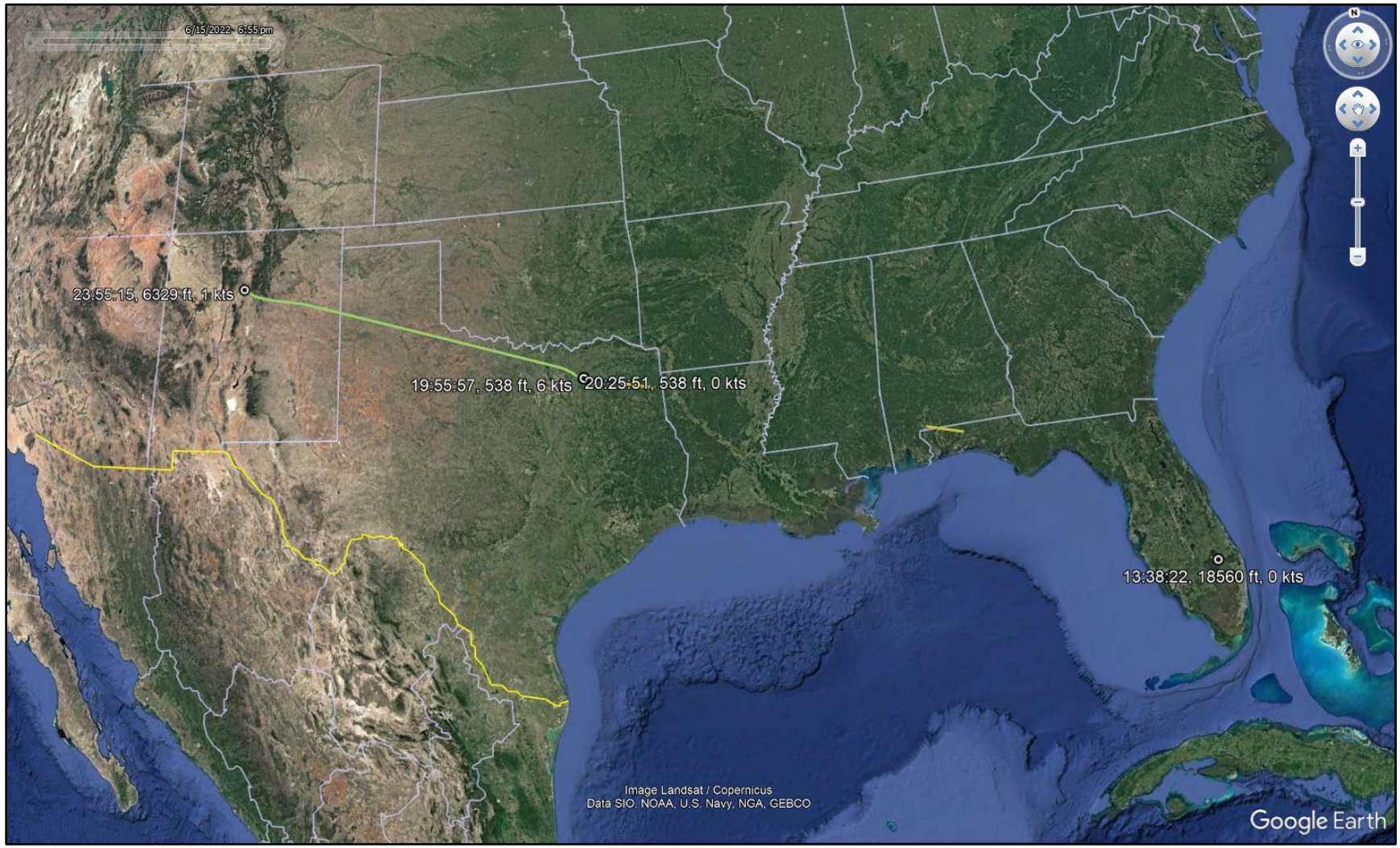

Figure 13. Plot of GPS tracklog recorded on June 13, 2022. The tracklog shows the aircraft traveling between southeast Florida and KSAF. The GPS indicated the aircraft stopped at KGVT. Note that due to discontinuities in the tracklog, it could not be conclusively determined from the GPS tracklog data if the aircraft stopped between southeast Florida and KGVT.

Figure 14. Plot of GPS tracklog data in the vicinity of KSAF on August 10, 2022.

Figure 15. Plot of GPS tracklog data from KSAF to the wreckage location (near KPIA) on the accident date (August 13, 2022).

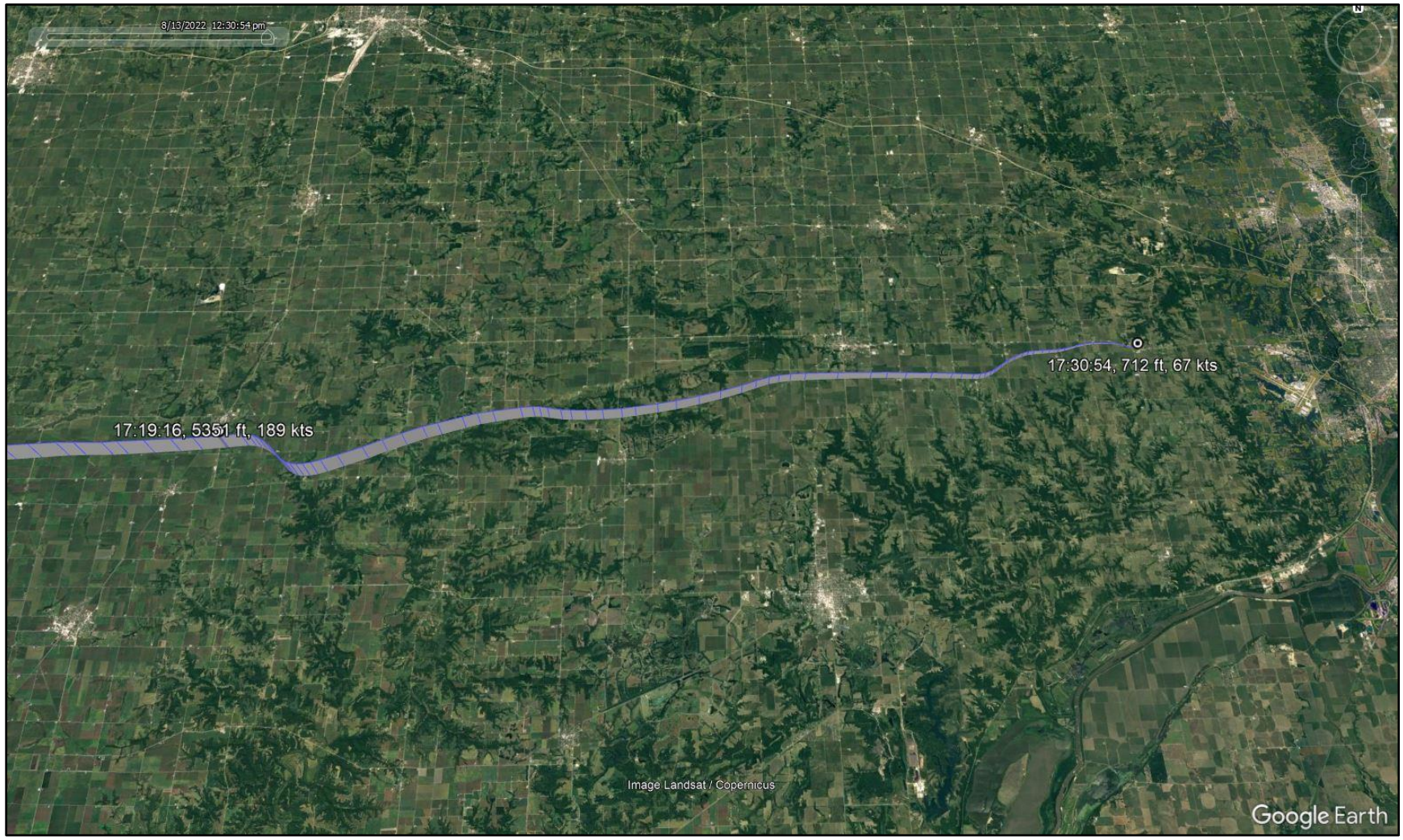

Figure 16. Plot of GPS tracklog as the aircraft groundtrack changed (around 17:19:16) as the aircraft descended to the last recorded tracklog point (17:30:54).

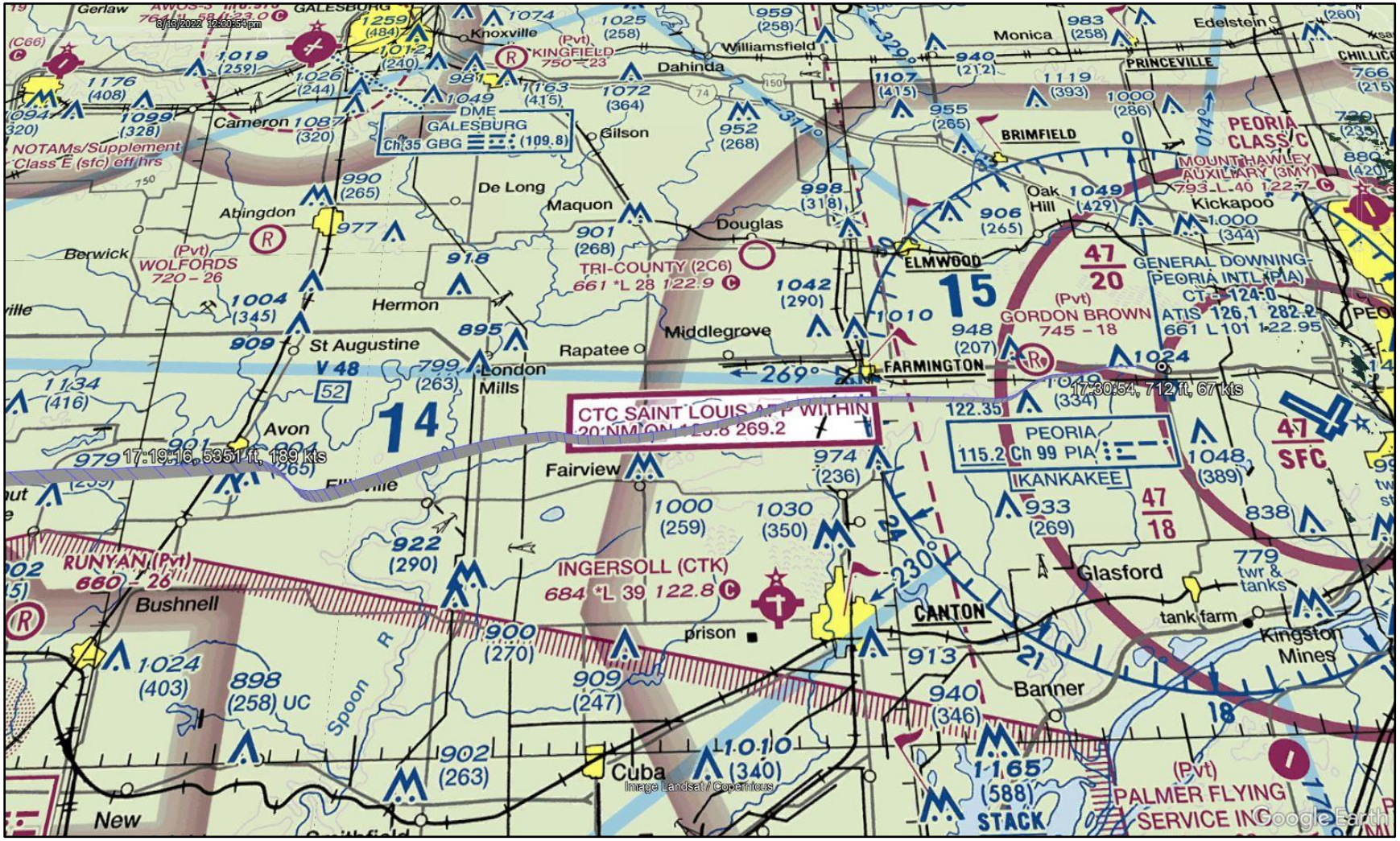

Figure 17. Plot of GPS tracklog data similar to figure 16, but overlaid on a sectional chart for the region.

Figure 18. An alternative view of the GPS tracklog data during the aircraft's descent to the accident site.

Figure 19. A detailed view of the tracklog data in the vicinity of the accident site. The wreckage location is shown as a yellow pin.